US009477337B2

(12) **United States Patent**
Cady et al.

(10) **Patent No.: US 9,477,337 B2**
(45) **Date of Patent: Oct. 25, 2016**

(54) **CONDUCTIVE TRACE ROUTING FOR DISPLAY AND BEZEL SENSORS**

(71) Applicant: **Microsoft Technology Licensing, LLC**, Redmond, WA (US)

(72) Inventors: **Andrew N. Cady**, Kirkland, WA (US); **Christopher A. Whitman**, Fort Collins, CO (US); **Steven Nabil Bathiche**, Kirkland, WA (US); **Thomas Charles Oliver**, Windsor, CO (US); **Rajesh Manohar Dighde**, Redmond, WA (US)

(73) Assignee: **Microsoft Technology Licensing, LLC**, Redmond, WA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 53 days.

(21) Appl. No.: **14/212,916**

(22) Filed: **Mar. 14, 2014**

(65) **Prior Publication Data**

US 2015/0261364 A1 Sep. 17, 2015

(51) **Int. Cl.**
G06F 3/041 (2006.01)
G06F 3/0488 (2013.01)

(52) **U.S. Cl.**
CPC ***G06F 3/0412*** (2013.01); ***G06F 3/0416*** (2013.01); ***G06F 3/0488*** (2013.01); *G06F 2203/04106* (2013.01)

(58) **Field of Classification Search**
CPC G06F 3/041; G06F 3/0412; G06F 3/0488; G06F 1/3262; G06F 2203/04101; G06F 2203/04103; G06F 2203/04106; G06F 2203/04108; G06F 3/0416
USPC 345/173, 174, 175
See application file for complete search history.

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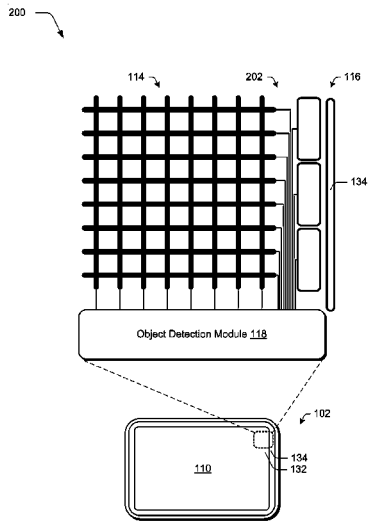
Primary Examiner — Tom Sheng
(74) *Attorney, Agent, or Firm* — Judy Yee; Micky Minhas

(57) **ABSTRACT**

Conductive trace routing techniques for display and bezel sensors are described. In one or more implementations, an apparatus includes display sensors, bezel sensors, and a plurality of conductive traces. The display sensors are configured to detect proximity of an object and are arranged in conjunction with a display area of a display device to support interaction with a user interface displayed by the display device. The bezel sensors are configured to detect proximity of an object and are disposed in a bezel that at least partially surrounds the display device and is outside the display area. The plurality of conductive traces are disposed between the display and bezel sensors and communicatively couple the display sensors and the bezel sensors to one or more computing components that are configured to process inputs received from the display sensors and the bezel sensors.

20 Claims, 7 Drawing Sheets



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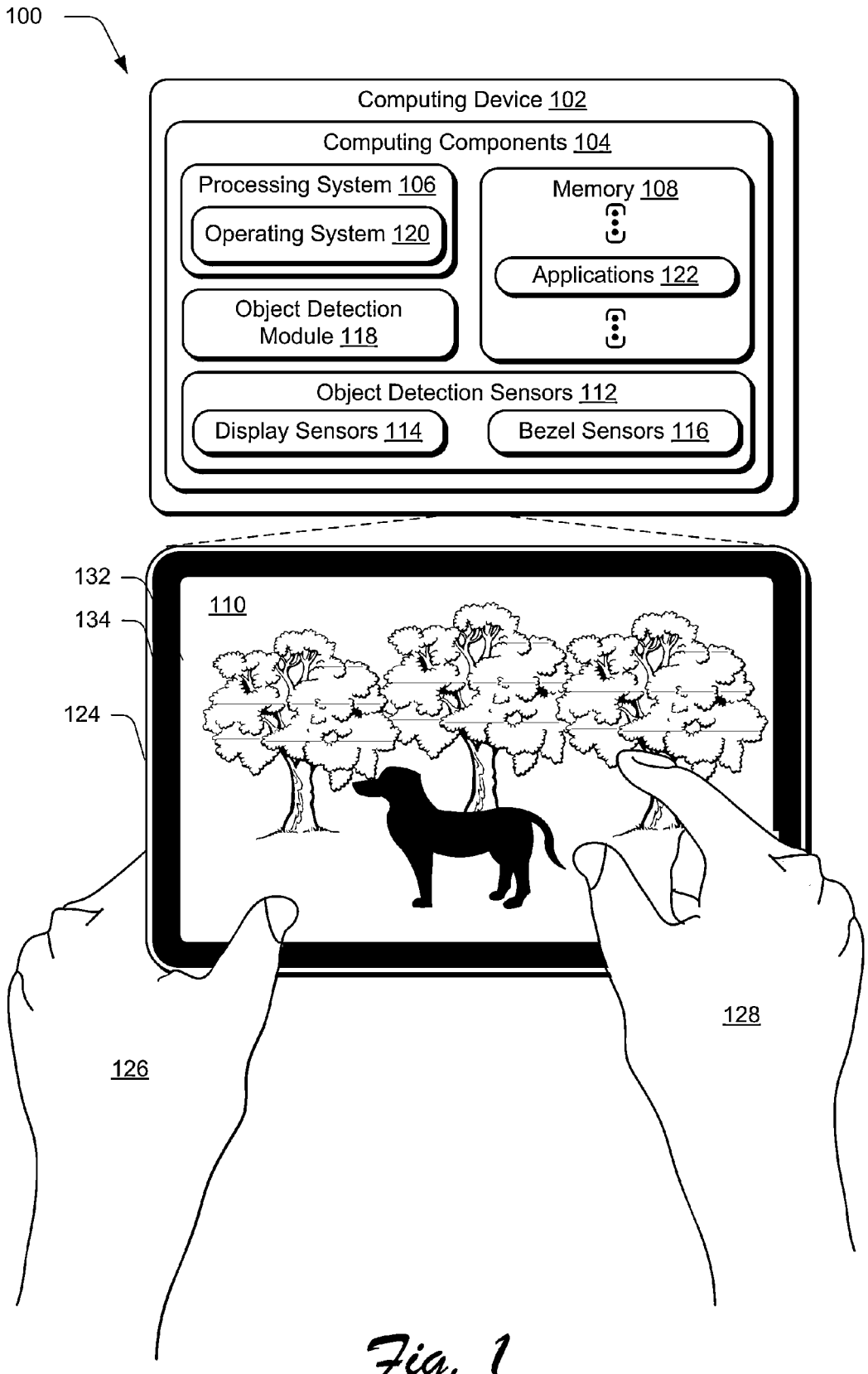

100
Computing Device 102
Computing Components 104
Processing System 106
Operating System 120
Object Detection Module 118
Memory 108
Applications 122
Object Detection Sensors 112
Display Sensors 114
Bezel Sensors 116
132
134
124
110
126
128

Fig. 1

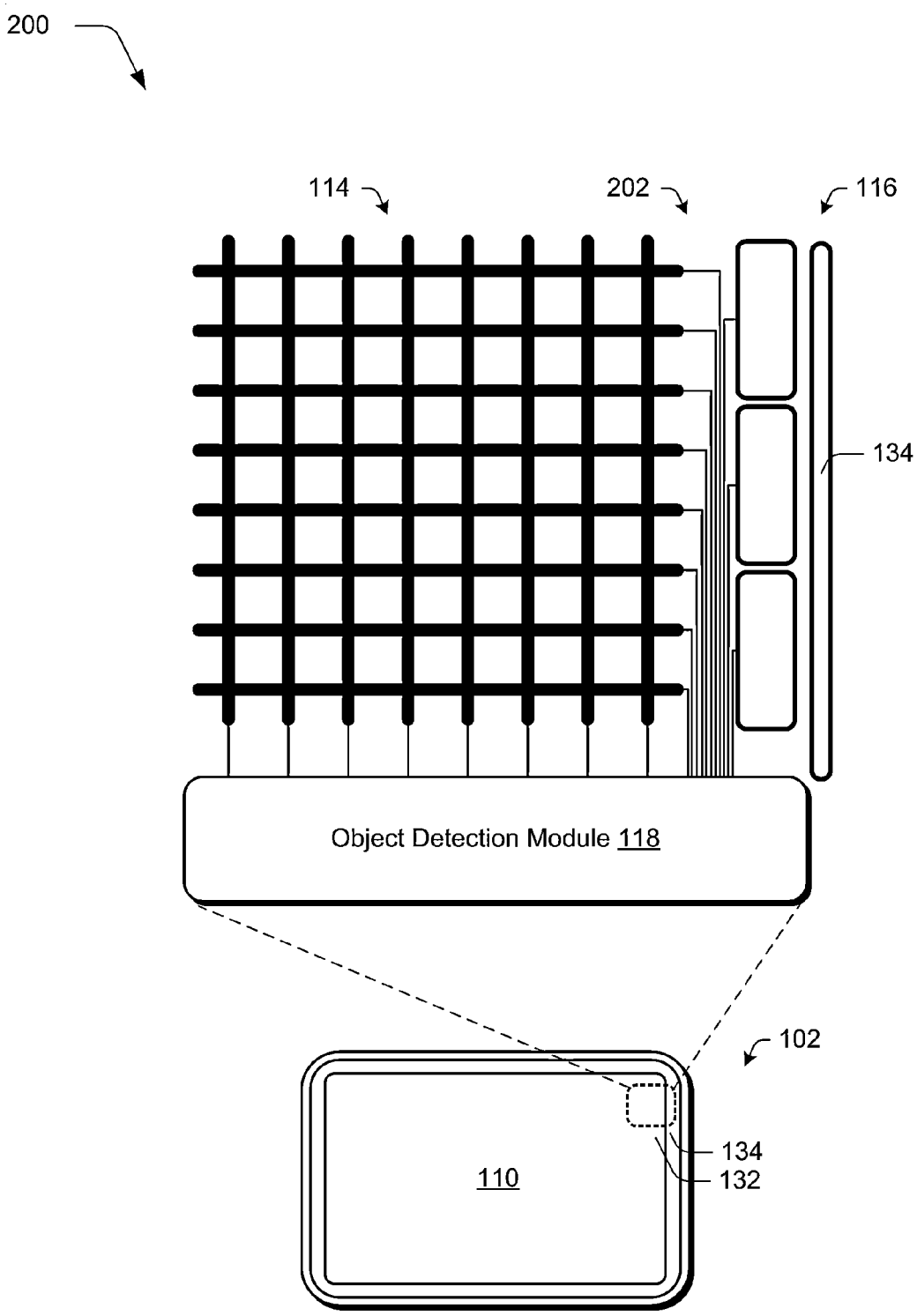

200
114
202
116
134
Object Detection Module 118
102
110
134
132

Fig. 2

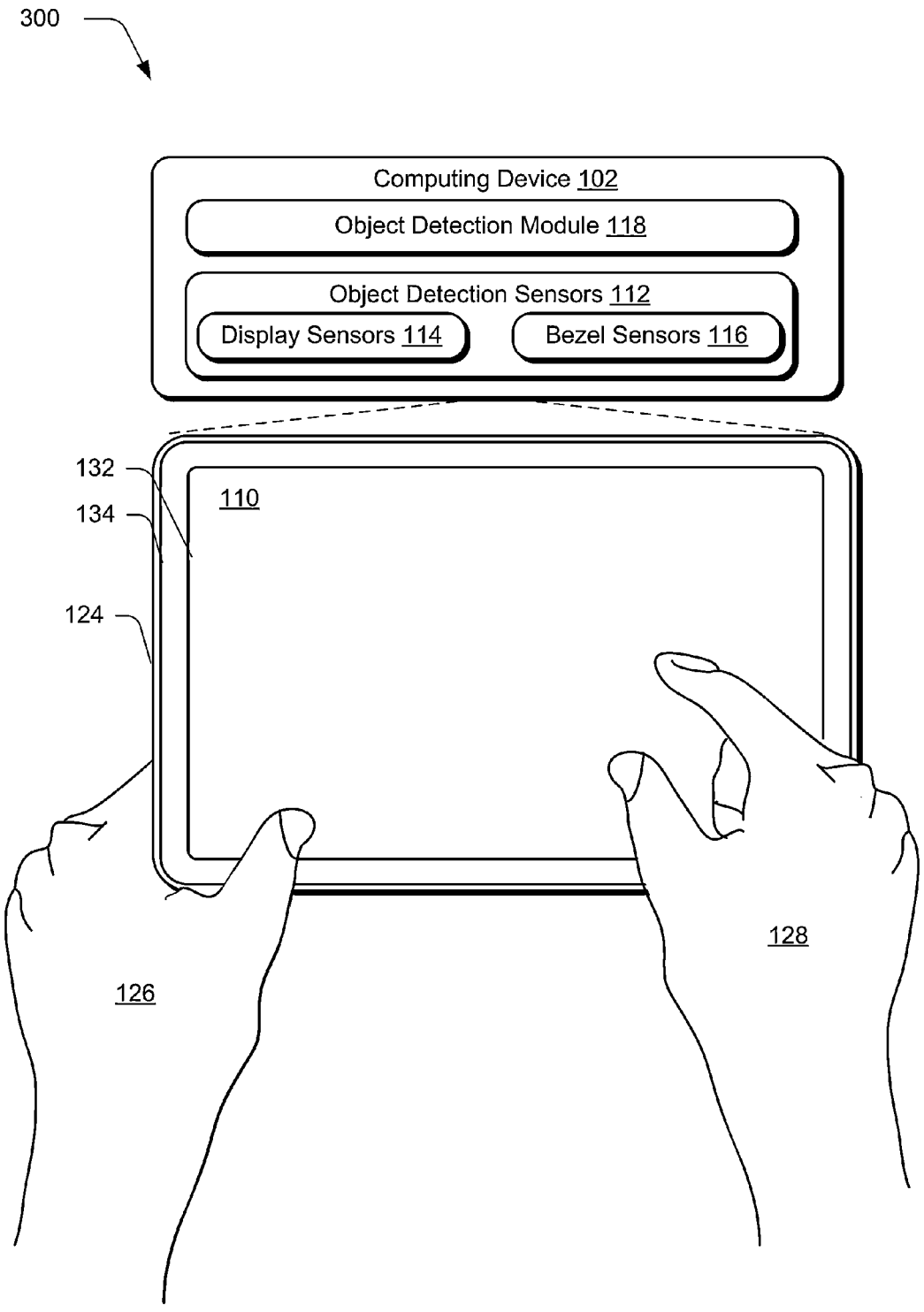

300
Computing Device 102
Object Detection Module 118
Object Detection Sensors 112
Display Sensors 114
Bezel Sensors 116
132
134
110
124
126
128

Fig. 3

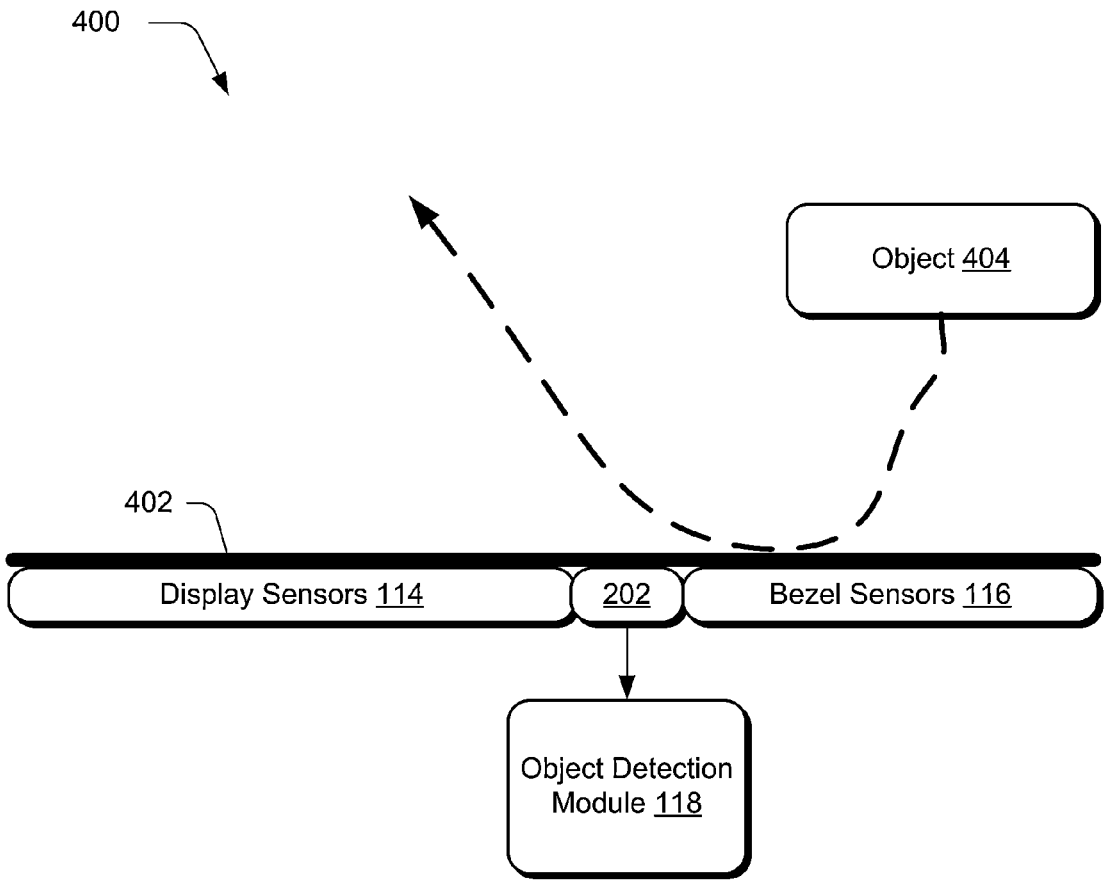
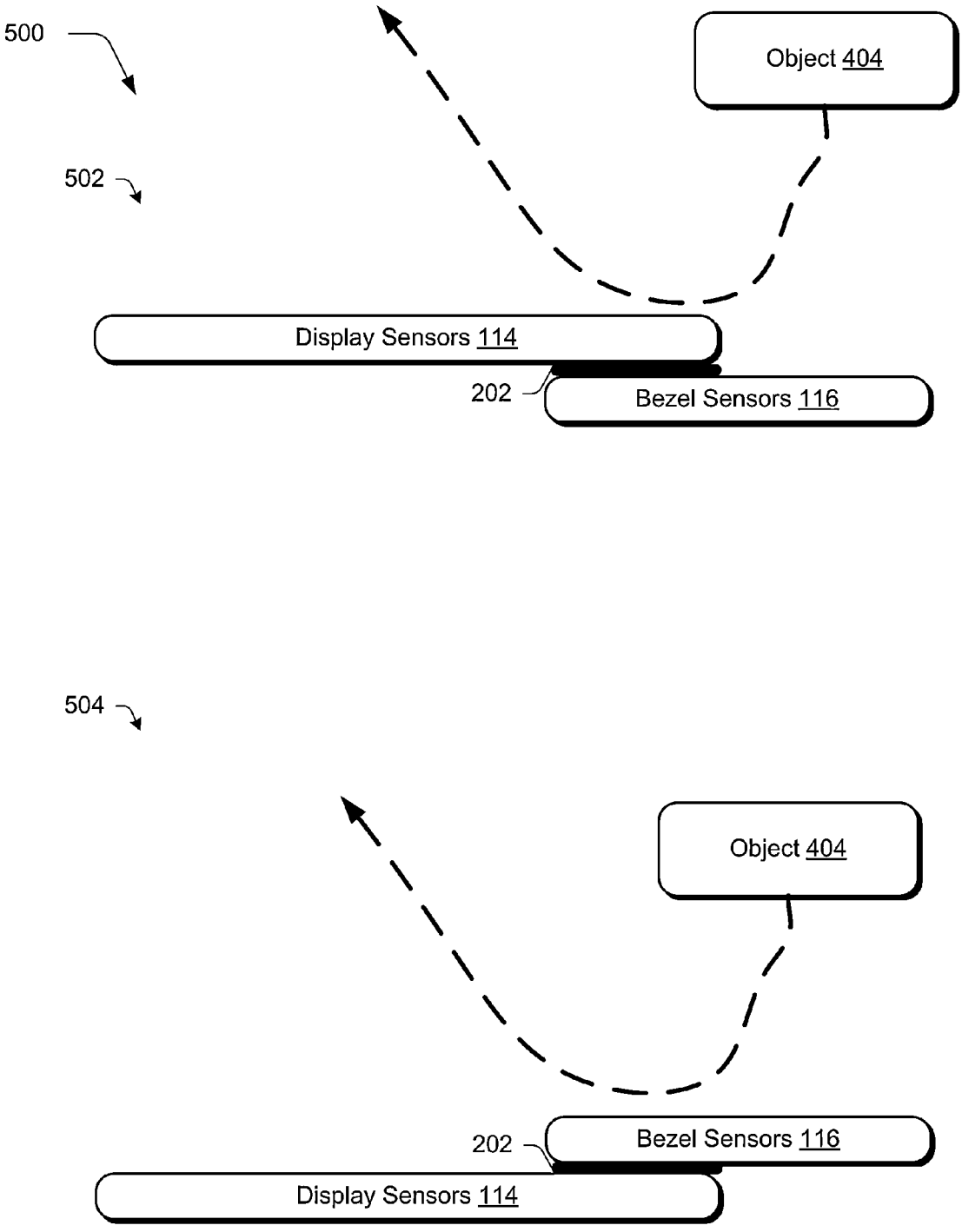

400
Object 404
402
Display Sensors 114
202
Bezel Sensors 116
Object Detection Module 118

Fig. 4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Object 404
502
Display Sensors 114
202
Bezel Sensors 116
504
Object 404
202
Bezel Sensors 116
Display Sensors 114

Fig. 5

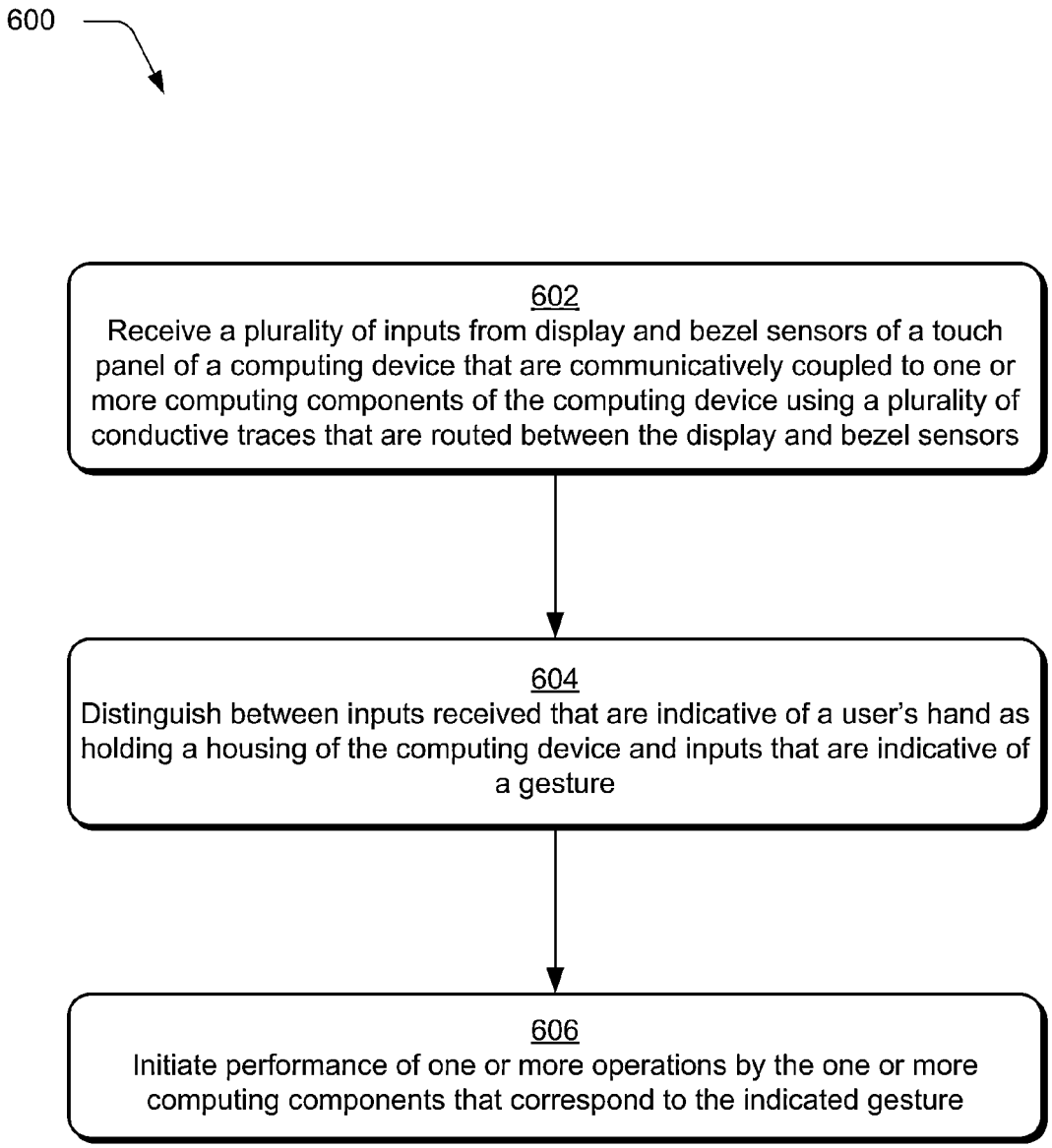
600
602
Receive a plurality of inputs from display and bezel sensors of a touch panel of a computing device that are communicatively coupled to one or more computing components of the computing device using a plurality of conductive traces that are routed between the display and bezel sensors
604
Distinguish between inputs received that are indicative of a user's hand as holding a housing of the computing device and inputs that are indicative of a gesture
606
Initiate performance of one or more operations by the one or more computing components that correspond to the indicated gesture

Fig. 6

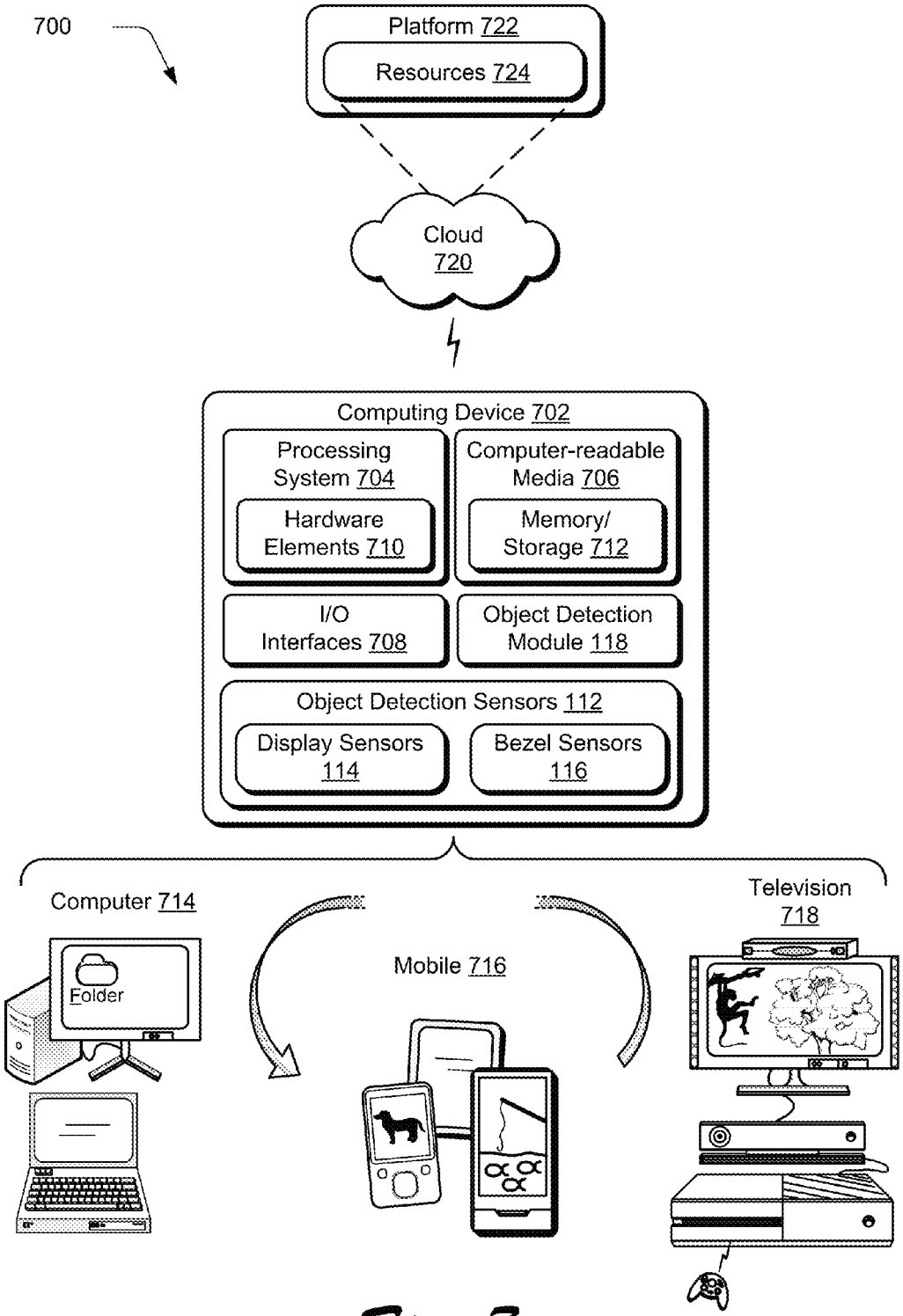
700
Platform 722
Resources 724
Cloud
720
Computing Device 702
Processing System 704
Hardware Elements 710
Computer-readable Media 706
Memory/ Storage 712
I/O Interfaces 708
Object Detection Module 118
Object Detection Sensors 112
Display Sensors 114
Bezel Sensors 116
Computer 714
Folder
Mobile 716
Television 718

Fig. 7

CONDUCTIVE TRACE ROUTING FOR DISPLAY AND BEZEL SENSORS

BACKGROUND

Touchscreen functionality has expanded the ways in which a user may interact with a device. One example of such functionality is the recognition of gestures, which may be performed to initiate corresponding operations of the computing device.

However, conventional techniques that were employed to support this interaction were often limited in how the gestures were detected, such as to use touchscreen functionality incorporated directly over a display portion a display device. Additionally, these conventional techniques were often static and thus did not address how the computing device was being used.

Consequently, even though gestures could expand the techniques via which a user may interact with a computing device, conventional implementations of these techniques often did not address how a user interacted with a device to perform these gestures, which could be frustrating to a user as well as inefficient.

SUMMARY

Conductive trace routing techniques for display and bezel sensors are described. In one or more implementations, an apparatus includes display sensors, bezel sensors, and a plurality of conductive traces. The display sensors are configured to detect proximity of an object and are arranged in conjunction with a display area of a display device to support interaction with a user interface displayed by the display device. The bezel sensors are configured to detect proximity of an object and are disposed in a bezel that at least partially surrounds the display device and is outside the display area. The plurality of conductive traces are disposed between the display and bezel sensors and communicatively couple the display sensors and the bezel sensors to one or more computing components that are configured to process inputs received from the display sensors and the bezel sensors.

In one or more implementations, a computing device includes a housing, a touch panel, one or more computing components implemented at least partially in hardware, and a plurality of conductive traces. The housing assumes a handheld form factor that is configured to be held by one or more hands of a user. The touch panel is secured to the housing and includes a display device, display sensors configured to detect proximity of an object and arranged in conjunction with a display area of display device, and bezel sensors disposed in a bezel of the touch panel that are also configured to detection proximity of an object. The one or more computing components are configured to process inputs received from the display and bezel sensors to identify gestures. The plurality of conductive traces are routed between the display and bezel sensors and communicatively couple the display sensors and the bezel sensors to the one or more computing components.

In one or more implementations, a plurality of inputs are received from display and bezel sensors of a touch panel of a computing device that are communicatively coupled to one or more computing components of the computing device using a plurality of conductive traces that are routed between the display and bezel sensors. The inputs are distinguished between inputs received that are indicative of a user's hand as holding a housing of the computing device and inputs that are indicative of a gesture. Performance of one or more operations by the one or more computing components is initiated that correspond to the indicated gesture.

This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

BRIEF DESCRIPTION OF THE DRAWINGS

The detailed description is described with reference to the accompanying figures. In the figures, the left-most digit(s) of a reference number identifies the figure in which the reference number first appears. The use of the same reference numbers in different instances in the description and the figures may indicate similar or identical items.

FIG. **1** is an illustration of an environment in an example implementation that is operable to employ the conductive trace routing and bezel sensor techniques described herein.

FIG. **2** depicts a system showing an example of a communicative coupling of the display and bezel sensors to the object detection module using a plurality of conductive traces.

FIG. **3** depicts an example implementation in which an object detection module is configured to distinguish and leverage inputs provided by display and bezel sensors to support interaction with the computing device of FIG. **1**.

FIG. **4** depicts an example system showing a cut-away view of the display and bezel sensors along with the plurality of conductive traces in a coplanar relationship.

FIG. **5** depicts an implementation showing first and second examples of arrangements of the display sensors, bezel sensors, and plurality of conductive traces in relation to each other.

FIG. **6** is a flow diagram depicting a procedure in an example implementation in which inputs are distinguished based on a likelihood of being indicative of a user's hand as holding a housing of a computing device and inputs that are likely indicative of a gesture.

FIG. **7** illustrates various components of an example device that can be implemented as any type of portable and/or computer device as described with reference to FIGS. **1-6** to implement embodiments of the conductive trace routing and bezel sensor techniques described herein.

DETAILED DESCRIPTION

Overview

Object detection sensors are configured to detect proximity of an object, such as a finger of a user's hand. These sensors may be incorporated as part of a display device to form a touch panel such that a user may interact "directly" with user interface elements (e.g., over a display of) displayed by a display device of the touch panel. Conventional techniques that were utilized to route conductive traces of the sensors involved routing of the traces along a perimeter of the touch panel. As such, these traces could prevent the extension of the sensors to an edge of the touch panel.

Conductive trace routing techniques for display and bezel sensors is described. In one or more implementations a touch panel includes display sensors and bezel sensors. The display sensors are configured to support interaction with a display area of a display device, such as with elements of a user interface as previously described. Bezel sensors are also

included that may be configured to detect proximity of an object. The bezel sensors are disposed in a bezel that at least partially surrounds the display area of the display device.

Conductive traces, that communicatively couple the display and bezel sensors to computing components of a computing device that includes the touch panel, are disposed in an area between the display and bezel sensors. In this way, the bezel sensors may be disposed near an edge of a housing of a computing device to support detection of an object near this edge and/or another display device. For example, the bezel sensors may be located in an area between two display devices to support touch functionality between the devices. Thus, the bezel sensors may be utilized to support a variety of functionality, such as to detect whether the computing device is being held by one or more hands of a user, for use of bezel gestures, specific absorption rate (SAR) management techniques, and so on as further described below.

In the following discussion, an example environment is first described that is operable to employ the conductive trace routing and bezel sensor techniques described herein. Example illustrations of the techniques and procedures are then described, which may be employed in the example environment as well as in other environments. Accordingly, the example environment is not limited to performing the example techniques and procedures. Likewise, the example techniques and procedures are not limited to implementation in the example environment.

Example Environment

FIG. **1** is an illustration of an environment **100** in an example implementation that is operable to employ the conductive trace routing and bezel sensor techniques described herein. The illustrated environment **100** includes a computing device **102**. In this example, the computing device **102** includes one or more computing components **104** that are implemented at least partially in hardware and are configured to perform and/or assist in performance of one or more operations of the computing device **102**, e.g., in execution of instructions specified by software. Examples of computing components **104** include a processing system **106**, memory **108**, a display device **110**, object detection sensors **112** that include display and bezel sensors **114**, **116** and an object detection module **118**. Examples of software that are executable on the processing system **106** and are storable in memory **108** include an operating system **120** and applications **122**.

The computing device **102** may be configured in a variety of ways. For example, a computing device may be configured as a computer that is capable of communicating over a network, such as a desktop computer, a mobile station, an entertainment appliance, a set-top box communicatively coupled to a display device, a wireless phone, a game console, portable music or game device, remote control, and so forth.

Thus, the computing device **102** may range from full resource devices with substantial memory and processor resources (e.g., personal computers, game consoles) to a low-resource device with limited memory and/or processing resources (e.g., traditional set-top boxes, hand-held game consoles). Additionally, although a single computing device **102** is shown, the computing device **102** may be representative of a plurality of different devices, such as a remote control and set-top box combination, a game console and game controller configuration, include peripheral devices, dedicated touchpad, and so on.

For example, the computing device **102** is illustrated as including a housing **124**, in which, the computing components **104** are disposed therein. The housing **124** is configured to support a handheld form factor such that the housing **124** may be held by a hand **126** of a user while supporting interaction with another hand **128** of the user, may be grasped by both hands **126**, **128** of a user, and so on.

In the illustrated example, a finger of a user's hand **128** is illustrated as interacting with a user interface displayed in a display area **130** of the display device **110**. This may be utilized to support a variety of different functionality, which may include interaction with user interface elements displayed on the display device **110**, recognition of gestures, and so on that include processing of inputs by an object detection module **118** to determine a location, at which, the object is detected.

For instance, proximity of an object, e.g., the finger of the user's hand **128**, may be detected by display sensors **114** that are disposed as proximal to the display area **132**. The display sensors **114** may be configured in a variety of different ways to detect proximity of an object, such as capacitive sensors, resistive sensors, acoustic sensors, image capture devices (e.g., sensor-in-a-pixel), and so forth such that the display sensors **114** do not obstruct a view by a user of the user interface in the display area **132** in this instance. A variety of other objects may also be detected, such as a stylus, and so on. Thus, in this example the display sensors **114** and the display device **110** are configured to form a touch panel to support touchscreen functionality.

The computing device **102** also includes bezel sensors **116** that are disposed in a bezel **134** that at least partially surrounds the display area **132** of the display device **110**. The bezel **134** and corresponding bezel sensors **116** may be included as part of the touch panel described earlier. The bezel **134**, however, may be configured such that a user interface is not displayable through the bezel **134**, which is illustrated in black in the figure. Other examples are also contemplated in which the bezel **134** may be utilized to display parts of a user interface, e.g., to indicate a position of a user's hand, include user interface elements, notifications, and so on.

The bezel sensors **116** of the bezel **134** may also be configured to detect proximity of an object, such as parts of a user's hand **128** as illustrated that are disposed over the bezel sensors **116**. Like the display sensors **114**, the bezel sensors **116** may be configured in a variety of ways, such as capacitive sensors, resistive sensors, acoustic sensors, image capture devices (e.g., sensor-in-a-pixel), thermal sensors, strain sensors, and so on.

Inputs from the bezel sensors **116** may also be processed by the object detection module **118** to determine a location at which the object is detected as proximal to the bezel **132**. For example, the object detection module **118** may include a single controller implemented in hardware that is configured to process inputs received from the bezel sensors **116**. In one or more implementations, this single controller of the object detection module **118** may also be configured to process inputs received from the display sensors **114**, which may be utilized to reduce overall cost and improve efficiency of the computing device **102**.

Other multi-controller examples are also contemplated, such as to reduce power consumption as further described below by keeping the bezel sensors **116** "active" while other computing components **104** are in a sleep state to initiate a "wake" of those components. The inputs from the bezel

sensors **116** may be processed singly or in combination with inputs received from the display sensors **114** as further described below.

A variety of different types of gestures may be recognized by the object detection module **118**, such a gestures that are recognized from a single type of input as well as gestures involving multiple types of inputs. For example, the computing device **102** may be configured to detect and differentiate between proximity to the display sensors **114** of the display device **110** from one or more bezel sensors **116** utilized to detect proximity of an object at a bezel **134** of the display device **110**. The differentiation may be performed in a variety of ways, such as by detecting a location at which the object is positioned, use of different sensors, and so on.

Thus, the object detection module **118** may support a variety of different gesture techniques by recognizing and leveraging a division between inputs received via a display portion **132** of the display device **110** and the bezel **134**. Consequently, the combination of display and bezel inputs may serve as a basis to indicate a variety of different gestures.

For instance, primitives of touch (e.g., tap, hold, two-finger hold, grab, cross, pinch, hand or finger postures, and so on) may be composed to create a space of intuitive and semantically rich gestures that are dependent on "where" these inputs are detected as well as which sensors were utilized in this detection. It should be noted that by differentiating between display and bezel inputs, the number of gestures that are made possible by each of these inputs alone is also increased. For example, although the movements may be the same, different gestures (or different parameters to analogous commands) may be indicated using inputs detected via the display **132** versus a bezel **134**.

Although the following discussion may describe specific examples of inputs, in instances the types of inputs may be switched (e.g., display may be used to replace bezel inputs and vice versa) and even removed (e.g., both inputs may be provided using either portion) without departing from the spirit and scope of the discussion.

FIG. **2** depicts a system **200** showing an example of a communicative coupling of the display and bezel sensors to the object detection module **118**. In this example, a section of a touch panel is shown in greater detail as including the display sensors **114** and the bezel sensors **116** from the display portion **132** and bezel of the display device **110**, respectively. The display and bezel sensors **114**, **116** may be configured as previously described to include matching techniques to detect proximity of an object, e.g., such that the display sensors **114** "extend into" the bezel **134** to support use as bezel sensors **116**.

The display sensors **114** may also be configured to detect proximity of an object in manner that is different than that used by the bezel sensors **116**, e.g., different types, patterns, and so on. In the illustration, for instance, the display sensors **114** may be configured as a grid (e.g., using indium tin oxide or "ITO") that is configured to detect proximity of an object at a variety of different locations using mutual capacitance. Mutual capacitance occurs between charge-holding objects such that current passes between the objects. For example, lines of the grid of the display sensors **114** may act as capacitor plates with a material disposed between the lines acting as a dielectric of a capacitor.

The bezel sensors **116**, however, may be configured to support direct capacitance that is discrete for individual ones of the bezel sensors **116**. Thus, in this example individual sensors of the bezel sensors **116** may be utilized to detect proximity of an object to the respective sensors. Detection by the bezel sensors **116** using direct capacitance may support a greater range of detection than that supported using mutual capacitance by the display sensors. This may be utilized to support a variety of different functionality, such as to detect proximity of an object as it approaches but does not contact a surface that includes the bezel sensors **116**, further discussion of which may be found in relation to a discussion of FIG. **4**.

The display sensors **114** and the bezel sensors **116** are illustrated as being communicatively coupled to the object detection module **118** using a plurality of conductive traces **202**. By routing the conductive traces **202** between the display and bezel sensors **114**, **116**, the bezel sensors **114** may be positioned adjacent to an edge of the housing **134**, as opposed to routing of the traces between the sensors and the housing as was conventionally performed. In this way, the bezel sensors **116** may be positioned relatively close to the edge of the housing **134** (e.g., within one millimeter) that was not feasible using conventional techniques. The "to the edge" location of the bezel sensors **116** along with the display sensors **114** may thus support an extended detection area that may be leveraged to support a variety of different functionality, further discussion of which may be found below and shown in an corresponding figure.

FIG. **3** depicts an example implementation **300** in which the object detection module **118** is configured to distinguish between and leverage inputs provided by the display and bezel sensors **114**, **116** to support interaction with the computing device **102**. The object detection module **118** may leverage the bezel sensors **116** along with the display sensors **114** to make a determination as to how interaction with the computing device **102** is performed.

In the illustrated example, for instance, inputs from the bezel and display sensors **114**, **116** may be processed by the object detection module **118** to make a determination that the housing **124** of the computing device **102** is likely held in the user's left hand **126**. Additionally, inputs from the bezel and display sensors **114**, **116** may also be processed to indicate that a fingertip of a user's hand **128** is detected by the display sensors **114** along with flat fingers and a palm of that user's right hand **128** by the display and bezel sensors **114**, **116**.

Thus, in this example the determination may cause inputs to be ignored that correspond to the left hand **126**. A determination may also be made to permit inputs that correspond to a fingertip of the user's right hand **128** but reject inputs from the palm and flat finger surfaces of that hand. Although this example describes restriction of inputs that are not likely related to a gesture, a variety of other examples are also contemplated, such as to orient a user interface based on how the computing device **102** is likely held, cause output of user interface elements at positions based on "where" the computing device is likely held, to manage wireless devices in accordance with specific absorption rate (SAR) considerations, and so forth as further described below.

A determination of which inputs to leverage (e.g., for recognition of a gesture, orientation of a user interface, and so on) may be made in a variety of ways. For example, a plurality of samples may be collected that involve different usage scenarios. These samples may then be processed using machine learning or other techniques to generate data that describes likely hand positions, orientations, and so on for inputs received from the sensors. Accuracy of a likely determination may be improved based on resolution of the inputs, e.g., the more bezel sensors **116** utilized in the bezel

134 the greater the likelihood of an accurate determination using inputs from these sensors.

Further, inputs from additional sensors may be leveraged to improve this determination, such as from sensors disposed on the sides and/or back of the housing **124**. In the illustrated example, for instance, sensors may be disposed on the sides of the housing **124** that are generally perpendicular to a plane of a surface of the display device **110** (e.g., at an angle of twenty-two degrees from a perpendicular plane to that of the display device), the back of the housing **124** that is defined as a plane generally perpendicular to the plane of the surface of the display device **110** (e.g., on an opposing side), and so on. Other examples of use of inputs received from the display and bezel sensors **114**, **116** are also contemplated as further described below.

FIG. **4** depicts an example system **400** showing a cut-away view of the display and bezel sensors along with the plurality of conductive traces **202** in a coplanar relationship. In this example, the display and bezel sensors **114**, **116** are formed along with the plurality of conductive traces **202** in a co-planar relationship on a substrate **402**, e.g., glass, plastic, and so on.

A grid of ITO, for instance, may be utilized to form the display sensors **114** as shown in FIG. **2**. Discrete sensing elements may also be formed from the ITO for the bezel sensors **116** on the substrate **402** along with the plurality of conductive traces **202**. The conductive traces **202** may be formed in a channel between the display and bezel sensors **114**, **116** such that these traces are also coplanar, one to another, and are formed without using "jumpers." In this way, overall thinness of the computing device **102** may be promoted by avoiding use of additional layers, thereby preserving a handheld form factor of the computing device **102**.

As previously described the bezel sensors **116** may be configured to support an increased sensing range in comparison with the display sensors **114** in one or more implementations. This increased sensing range may be utilized in a variety of ways, such as to detect an object **404** such as a palm of a user's hand and thereby reject inputs that correspond to detection of that object before contact with a surface of the computing device **102** and/or detection by the display sensors **114**.

Additionally, the machine learning techniques may also be employed to manage computing device **102** operation based on detection of the object **404**, which may include movement of the object in relation to the object detection sensors **112**. For example, the bezel sensors **116** may be configured to consume less power than the display sensors **114**. As such, the bezel sensors **116** may operate in a polling fashion by "waking" at periodic intervals to determine if an object **404** is proximal while other component components **104** are in a sleep state. If so, this detection by the object detection module **118** may then cause other computing components **104** that are in the sleep state (e.g., hibernation state) to "wake" to support user interaction. Movement of the object **404** may also assist on this determination, such as toward or away from the bezel sensors **116** as illustrated by the phantom line in the figure.

Thus, in this example, the object detections sensors **112** may be utilized to determine a likely location of the object **404** as well as orientation of the computing device **102** itself in relation to the object **404**. This may also be leveraged as part of specific absorption rate (SAR) management of computing components **104** of the computing device **102** that emit radiation, e.g., wireless communication components. For instance, the object detection module **118** may indicate that an object **404** is disposed proximal to the computing device **102**, antennas of the computing device **102**, and so on. This indication may then be leveraged by the computing device **102** (e.g., operating system **120**, applications **122**, and so on) to reduce an amount of radiation emitted by a Wi-Fi® network connection device, Bluetooth® wireless connection device, and so on. Further, this indication may be leveraged with the indication of movement to support further functionality, e.g., permit higher emissions as the object **404** is moved away as opposed to when the object **404** is moved toward the sensors, and so forth. Although a coplanar relationship was described in this example **400**, non-coplanar relationships between the display sensors **114**, bezel sensors **116**, and plurality of conductive traces **202** are also contemplated without departing from the spirit and scope thereof, an example of which is described as follows and shown in a corresponding figure.

FIG. **5** depicts an implementation **500** showing first and second examples **502**, **502** or arrangements of the display sensors **114**, bezel sensors **116**, and plurality of conductive traces **202** in relation to each other. In the first example **502**, an overlapping arrangement of the display sensors **114** and the bezel sensors **116** is shown in which the plurality of conductive traces **202** are also disposed between these sensors. In this example, the display sensors **114** are disposed on a plane that is closer to an object **404** to be detected than a plane that includes the bezel sensors **116**.

The second example **504** also includes an overlapping arrangement, but in this instance the bezel sensors **116** are disposed on a plane that is closer to an object **404** to be detected than a plane that includes the display sensors **114**. A variety of other examples of arrangements are also contemplated as further described in relation to the following procedures.

Example Procedures

The following discussion describes bezel sensor and conductive trace routing techniques that may be implemented utilizing the previously described systems and devices. Aspects of each of the procedures may be implemented in hardware, firmware, or software, or a combination thereof. The procedures are shown as a set of blocks that specify operations performed by one or more devices and are not necessarily limited to the orders shown for performing the operations by the respective blocks. In portions of the following discussion, reference will be made to FIGS. **1**-**5**.

FIG. **6** depicts a procedure **600** in an example implementation in which inputs are distinguished based on a likelihood of being indicative of a user's hand as holding a housing of a computing device and inputs that are likely indicative of a gesture. A plurality of inputs are received from display and bezel sensors of a touch panel of a computing device that are communicatively coupled to one or more computing components of the computing device using a plurality of conductive traces that are routed between the display and bezel sensors (block **602**). As shown in FIGS. **4** and **5**, for instance, the conductive traces **202** may be routed between the display and bezel sensors **114**, **116** in a coplanar relationship, multi-planar relationship, and so on. In this way, the bezel sensors **116** may be positioned closer to an edge of the housing **124** than would otherwise be possible if the traces were routed along the "outside" of the sensors.

Inputs are distinguished between inputs received that are indicative of a user's hand as holding a housing of the computing device and inputs that are indicative of a gesture

(block **604**). Data generated from machine learning, for instance, may be leveraged by an object detection module **118** to determine a likelihood that inputs correspond to gestures versus those cause by a user holding the device and thus are not desired on the part of a user to initiate an operation of the device. Performance of one or more operations is then initiated by the one or more computing components that correspond to the indicated gesture (block **606**), such as to navigate through a user interface, select particular items, and so on.

Example System and Device

FIG. **7** illustrates an example system generally at **700** that includes an example computing device **702** that is representative of one or more computing systems and/or devices that may implement the various techniques described herein. The computing device **702** may be, for example, a server of a service provider, a device associated with a client (e.g., a client device), an on-chip system, and/or any other suitable computing device or computing system that includes computing components **104** as described above.

The example computing device **702** as illustrated includes a processing system **704**, one or more computer-readable media **706**, and one or more I/O interface **708** that are communicatively coupled, one to another. Although not shown, the computing device **702** may further include a system bus or other data and command transfer system that couples the various components, one to another. A system bus can include any one or combination of different bus structures, such as a memory bus or memory controller, a peripheral bus, a universal serial bus, and/or a processor or local bus that utilizes any of a variety of bus architectures. A variety of other examples are also contemplated, such as control and data lines.

The processing system **704** is representative of functionality to perform one or more operations using hardware. Accordingly, the processing system **704** is illustrated as including hardware element **710** that may be configured as processors, functional blocks, and so forth. This may include implementation in hardware as an application specific integrated circuit or other logic device formed using one or more semiconductors. The hardware elements **710** are not limited by the materials from which they are formed or the processing mechanisms employed therein. For example, processors may be comprised of semiconductor(s) and/or transistors (e.g., electronic integrated circuits (ICs)). In such a context, processor-executable instructions may be electronically-executable instructions.

The computer-readable storage media **706** is illustrated as including memory/storage **712**. The memory/storage **712** represents memory/storage capacity associated with one or more computer-readable media. The memory/storage component **712** may include volatile media (such as random access memory (RAM)) and/or nonvolatile media (such as read only memory (ROM), Flash memory, optical disks, magnetic disks, and so forth). The memory/storage component **712** may include fixed media (e.g., RAM, ROM, a fixed hard drive, and so on) as well as removable media (e.g., Flash memory, a removable hard drive, an optical disc, and so forth). The computer-readable media **706** may be configured in a variety of other ways as further described below.

Input/output interface(s) **708** are representative of functionality to allow a user to enter commands and information to computing device **702**, and also allow information to be presented to the user and/or other components or devices using various input/output devices. Examples of input devices include a keyboard, a cursor control device (e.g., a mouse), a microphone, a scanner, touch functionality (e.g., capacitive or other sensors that are configured to detect physical touch), a camera (e.g., which may employ visible or non-visible wavelengths such as infrared frequencies to recognize movement as gestures that do not involve touch), and so forth. Examples of output devices include a display device (e.g., a monitor or projector), speakers, a printer, a network card, tactile-response device, and so forth. Thus, the computing device **702** may be configured in a variety of ways as further described below to support user interaction.

Various techniques may be described herein in the general context of software, hardware elements, or program modules. Generally, such modules include routines, programs, objects, elements, components, data structures, and so forth that perform particular tasks or implement particular abstract data types. The terms "module," "functionality," and "component" as used herein generally represent software, firmware, hardware, or a combination thereof. The features of the techniques described herein are platform-independent, meaning that the techniques may be implemented on a variety of commercial computing platforms having a variety of processors.

An implementation of the described modules and techniques may be stored on or transmitted across some form of computer-readable media. The computer-readable media may include a variety of media that may be accessed by the computing device **702**. By way of example, and not limitation, computer-readable media may include "computer-readable storage media" and "computer-readable signal media."

"Computer-readable storage media" may refer to media and/or devices that enable persistent and/or non-transitory storage of information in contrast to mere signal transmission, carrier waves, or signals per se. Thus, computer-readable storage media refers to non-signal bearing media. The computer-readable storage media includes hardware such as volatile and non-volatile, removable and non-removable media and/or storage devices implemented in a method or technology suitable for storage of information such as computer readable instructions, data structures, program modules, logic elements/circuits, or other data. Examples of computer-readable storage media may include, but are not limited to, RAM, ROM, EEPROM, flash memory or other memory technology, CD-ROM, digital versatile disks (DVD) or other optical storage, hard disks, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or other storage device, tangible media, or article of manufacture suitable to store the desired information and which may be accessed by a computer.

"Computer-readable signal media" may refer to a signal-bearing medium that is configured to transmit instructions to the hardware of the computing device **702**, such as via a network. Signal media typically may embody computer readable instructions, data structures, program modules, or other data in a modulated data signal, such as carrier waves, data signals, or other transport mechanism. Signal media also include any information delivery media. The term "modulated data signal" means a signal that has one or more of its characteristics set or changed in such a manner as to encode information in the signal. By way of example, and not limitation, communication media include wired media such as a wired network or direct-wired connection, and wireless media such as acoustic, RF, infrared, and other wireless media.

As previously described, hardware elements **710** and computer-readable media **706** are representative of modules,

programmable device logic and/or fixed device logic implemented in a hardware form that may be employed in some embodiments to implement at least some aspects of the techniques described herein, such as to perform one or more instructions. Hardware may include components of an integrated circuit or on-chip system, an application-specific integrated circuit (ASIC), a field-programmable gate array (FPGA), a complex programmable logic device (CPLD), and other implementations in silicon or other hardware. In this context, hardware may operate as a processing device that performs program tasks defined by instructions and/or logic embodied by the hardware as well as a hardware utilized to store instructions for execution, e.g., the computer-readable storage media described previously.

Combinations of the foregoing may also be employed to implement various techniques described herein. Accordingly, software, hardware, or executable modules may be implemented as one or more instructions and/or logic embodied on some form of computer-readable storage media and/or by one or more hardware elements **710**. The computing device **702** may be configured to implement particular instructions and/or functions corresponding to the software and/or hardware modules. Accordingly, implementation of a module that is executable by the computing device **702** as software may be achieved at least partially in hardware, e.g., through use of computer-readable storage media and/or hardware elements **710** of the processing system **704**. The instructions and/or functions may be executable/operable by one or more articles of manufacture (for example, one or more computing devices **702** and/or processing systems **704**) to implement techniques, modules, and examples described herein.

As further illustrated in FIG. **7**, the example system **700** enables ubiquitous environments for a seamless user experience when running applications on a personal computer (PC), a television device, and/or a mobile device. Services and applications run substantially similar in all three environments for a common user experience when transitioning from one device to the next while utilizing an application, playing a video game, watching a video, and so on.

In the example system **700**, multiple devices are interconnected through a central computing device. The central computing device may be local to the multiple devices or may be located remotely from the multiple devices. In one embodiment, the central computing device may be a cloud of one or more server computers that are connected to the multiple devices through a network, the Internet, or other data communication link.

In one embodiment, this interconnection architecture enables functionality to be delivered across multiple devices to provide a common and seamless experience to a user of the multiple devices. Each of the multiple devices may have different physical requirements and capabilities, and the central computing device uses a platform to enable the delivery of an experience to the device that is both tailored to the device and yet common to all devices. In one embodiment, a class of target devices is created and experiences are tailored to the generic class of devices. A class of devices may be defined by physical features, types of usage, or other common characteristics of the devices.

In various implementations, the computing device **702** may assume a variety of different configurations, such as for computer **714**, mobile **716**, and television **718** uses. Each of these configurations includes devices that may have generally different constructs and capabilities, and thus the computing device **702** may be configured according to one or more of the different device classes. For instance, the computing device **702** may be implemented as the computer **714** class of a device that includes a personal computer, desktop computer, a multi-screen computer, laptop computer, netbook, and so on.

The computing device **702** may also be implemented as the mobile **716** class of device that includes mobile devices, such as a mobile phone, portable music player, portable gaming device, a tablet computer, a multi-screen computer, and so on. The computing device **702** may also be implemented as the television **718** class of device that includes devices having or connected to generally larger screens in casual viewing environments. These devices include televisions, set-top boxes, gaming consoles, and so on.

The techniques described herein may be supported by these various configurations of the computing device **702** and are not limited to the specific examples of the techniques described herein. This functionality may also be implemented all or in part through use of a distributed system, such as over a "cloud" **720** via a platform **722** as described below.

The cloud **720** includes and/or is representative of a platform **722** for resources **724**. The platform **722** abstracts underlying functionality of hardware (e.g., servers) and software resources of the cloud **720**. The resources **724** may include applications and/or data that can be utilized while computer processing is executed on servers that are remote from the computing device **702**. Resources **724** can also include services provided over the Internet and/or through a subscriber network, such as a cellular or Wi-Fi network.

The platform **722** may abstract resources and functions to connect the computing device **702** with other computing devices. The platform **722** may also serve to abstract scaling of resources to provide a corresponding level of scale to encountered demand for the resources **724** that are implemented via the platform **722**. Accordingly, in an interconnected device embodiment, implementation of functionality described herein may be distributed throughout the system **700**. For example, the functionality may be implemented in part on the computing device **702** as well as via the platform **722** that abstracts the functionality of the cloud **720**.

CONCLUSION

Although the invention has been described in language specific to structural features and/or methodological acts, it is to be understood that the invention defined in the appended claims is not necessarily limited to the specific features or acts described. Rather, the specific features and acts are disclosed as example forms of implementing the claimed invention.

What is claimed is:

1. An apparatus comprising:

display sensors configured to detect proximity of an object, the display sensors arranged in conjunction with a display area of display device to support interaction with a user interface displayed by the display device;

bezel sensors configured to detect proximity of an object, with a different type of sensing than is used for detection by the display sensors and with a detection range greater than that of the display sensors the bezel sensors disposed in a bezel that at least partially surrounds the display device and is outside the display area; and

a plurality of conductive traces, disposed between the display and bezel sensors, that communicatively couple the display sensors and the bezel sensors to one or more

computing components that are configured to process inputs received from the display sensors and the bezel sensors.

2. An apparatus as described in claim **1**, wherein the conductive traces, the bezel sensors, and the plurality of conductive traces are at least partially coplanar.

3. An apparatus as described in claim **1**, wherein the display sensors are configured to detect the proximity of the object using mutual capacitance.

4. An apparatus as described in claim **1**, wherein the bezel sensors are configured to detect the proximity of the object using direct capacitance.

5. An apparatus as described in claim **1**, wherein the plurality of conductive traces are formed in a channel located between the display sensors and bezel sensors.

6. An apparatus as described in claim **1**, wherein the one or more computing components include an object detection module that is configured to process the inputs to determine a likely location of the object in relation to the display sensors and the bezel sensors.

7. An apparatus as described in claim **6**, wherein the object detection module is configured to identify that a computing device that includes the display sensors, display device, plurality of conductive traces, and bezel sensors is being held by one or more hands of a user from inputs received from the bezel sensors.

8. An apparatus as described in claim **6**, wherein the object detection module is configured to recognize a gesture from inputs received from both the display and bezel sensors.

9. An apparatus as described in claim **6**, wherein the object detection module is configured to manage radiation emission by one or more wireless devices responsive to the detection of the proximity of the object to the display sensors or the bezel sensors.

10. An apparatus as described in claim **1**, wherein the display sensors, plurality of conductive traces, and bezel sensors are formed on a surface of a single substrate.

11. An apparatus as described in claim **1**, further comprising a second display device and wherein the bezel sensors are disposed between the display device and the second display device.

12. A computing device comprising:

a housing assuming a handheld form factor that is configured to be held by one or more hands of a user;

a touch panel secured to the housing that includes a display device, display sensors configured to detect proximity of an object and arranged in conjunction with a display area of display device, and bezel sensors disposed in a bezel of the touch panel that are also configured to detect proximity of an object with a different type of sensing than is used for detection by the display sensors and with a detection range greater than that of the display sensors;

one or more computing components implemented at least partially in hardware and disposed within the housing, the one or more computing components configured to process inputs received from the display and bezel sensors to identify gestures; and

a plurality of conductive traces, routed between the display and bezel sensors, that communicatively couple the display sensors and the bezel sensors to the one or more computing components.

13. A computing device as described in claim **12**, wherein the bezel sensors are disposed proximal to an edge of the housing.

14. A computing device as described in claim **13**, wherein the bezel sensors are within a distance of one millimeter to the edge of the housing.

15. A computing device as described in claim **13**, wherein the one or more computing components are configured to identify that the housing is being held by one or more hands of a user from inputs received from the bezel sensors.

16. A computing device as described in claim **15**, wherein the identification is performed by the one or more computing components using data generated using machine learning.

17. A computing device as described in claim **13**, wherein the one or more computing components are configured to recognize a gesture from inputs received from both the display and bezel sensors.

18. A computing device as described in claim **13** wherein the one or more computing components are configured to manage radiation emission by one or more wireless devices responsive to the detection of the proximity of the object to the display sensors or the bezel sensors.

19. A method comprising:

receiving a plurality of inputs from display and bezel sensors of a touch panel of a computing device that are communicatively coupled to one or more computing components of the computing device using a plurality of conductive traces that are routed between the display and bezel sensors the bezel sensors using a different type of sensing than is used for detection by the display sensors and having a detection range greater than that of the display sensors;

distinguishing between inputs received that are indicative of a user's hand as holding a housing of the computing device and inputs that are indicative of a gesture; and

initiating performance of one or more operations by the one or more computing components that correspond to the indicated gesture.

20. A method as described in claim **19**, further comprising detecting proximity of an object using one or more additional sensors disposed on a side or rear of the housing of the computing device and wherein the distinguishing is performed based at least in part on the detecting.

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